



**CITY OF PENDLETON
AQUIFER STORAGE AND RECOVERY
(ASR) PROJECT
FOURTH ANNUAL REPORT
PILOT TEST, CYCLE 5**

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PROJECT
FOURTH ANNUAL REPORT, PILOT TEST, CYCLE 5**

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EXECUTIVE SUMMARY

The City of Pendleton continues to store high-quality drinking water produced in its membrane filtration water treatment plant in the basalt aquifer system beneath the City. That water is stored during the winter months when there is adequate water in the Umatilla River to provide both for the City's needs and to store excess water in the aquifer. The stored water is recovered during the summer months when demand is high. The process is referred to as Aquifer Storage and Recovery (ASR).

The City began the pilot testing phase of the ASR project in December of 2003. The first phase, Cycle 1, was a brief recharge-storage-recovery cycle to observe hydraulic response in the aquifer. Cycle 1 was completed with assistance from CH2M HILL. The second phase, Cycle 2, began with recharge in January, 2004, continued through storage and recovery, and ended in September, 2004. The third phase, Cycle 3, began with recharge in December, 2004, continued through storage and recovery, and ended in September, 2005. The fourth phase, Cycle 4, began with recharge in December, 2005, continued through storage and recovery, and ended in September, 2006. Pilot tests for Cycle 2, Cycle 3, and Cycle 4 were completed by City staff.

The fifth phase, Cycle 5, of the ASR pilot test began on December 14, 2006 with aquifer recharge at two sites, production well # 1 (Byers Well) and production well # 5 (Stillman Well). Recharge at these wells continued for 136 days until May 14, 2007. Water was stored for a brief, one-day period, and then recovery pumping from Well # 1 began on May 15, 2007. Aquifer recharge was also conducted at a third well, Well # 14, from March 28, 2007 until May 14, 2007. Recovery pumping from Well # 14 began on May 15, 2007 and ended on September 10, 2007. Recovered water is added to the City's distribution system. The recharge rate at Byers Well and Well # 14 is constant; the recharge rate at Stillman is variable. The Cycle 5 pilot test was completed by City staff.

The City has met several of its objectives with the ASR project. The ASR project allows the City to maximize the effectiveness of the membrane filtration water treatment plant (WTP) by operating the plant at full capacity during the winter and spring months when water rights allow and flow is high in the Umatilla River. The project has demonstrated that Byers Well, Stillman Well, and Well # 14 are capable of storing large volumes of high quality drinking water in the aquifer system beneath the City. Recovery from Byers Well for all five cycles has been very successful. Recovery from Well # 14 during 2007 was successful. However, the City experienced problems during Cycles 4 and 5 with recovery from Stillman Well due to air entrainment issues and is currently exploring alternatives to address the problem.

During the 2007 water year and ASR Cycle 5, the City recharged and stored 390.333 MG (million gallons). The City recovered 239.633 MG to the distribution system and another 29.4 MG was flushed to waste. Overall 68.9% of the water stored was pumped from the ASR wells. At Byers Well (Well # 1), 216.75 MG was stored and a total of 258.209 MG was pumped from Byers Well. At Stillman Well (Well # 5), 150.70 MG was stored, but none was recovered to the distribution system due to problems with entrained air at the well. Only 29.40 MG was pumped from Stillman Well between January 29, 2007 and June 22, 2007, and

it was all pumped to waste. At Well # 14, 22.883 MG was stored and a total of 34.394 MG was pumped from Well # 14 during the 2007 water year.

For the overall water supply during the 2007 water year and ASR Cycle 5, the City supplied about 1,644.44 MG to the distribution system. Of this total, about 67.9% (1,116.576 MG) was surface water and about 32.1% (527.864 MG) was native groundwater. During the four-year ASR project, the overall water supplied to the distribution system has been about 6,298 MG. Of this total, 74.4% (4,685 MG) has been surface water and 25.6% (1,613 MG) has been native groundwater. Prior to the ASR program, the City derived about 62% of its supply from native groundwater and about 38% from the City's old "Springs" source. Since the ASR program began, the City has been able to reverse this trend of groundwater and surface water usage and now relies primarily on surface water.

Cycle 1 baseline static levels, recorded in December, 2003 before Cycle 1 recharge began, were 809 feet for Byers and 811 feet for Stillman. Cycle 2 pre-recharge static levels, which were recorded just after Cycle 1 pumping ended and just before Cycle 2 recharge began in late 2003 and early 2004, were approximately 812 feet at both wells. Cycle 3 pre-recharge static levels were 805 and 809 feet for Byers and Stillman, respectively. Cycle 4 pre-recharge static water levels at Byers and Stillman wells were 803.7 and 802.9 feet, respectively. Cycle 5 pre-recharge static levels at Byers and Stillman were 803.1 and 802.2 feet, respectively. Cycle 5 pre-recharge static levels at Byers and Stillman were 803.1 and 802.2 feet respectively. Cycle 6 pre-recharge static levels at Byers and Stillman, which were made in late 2007 just before Cycle 6 recharge began, were 801.0 and 804.2, respectively. This indicates a decline of about 2 feet at Byers and an increase of about 2 feet at Stillman. In 2006, the pre-cycle 5 water level at Well # 14 was 809.8 ft; in 2007, the pre-cycle 6 water level at Well # 14 was 807.7 ft. This indicates a decline of about 2 feet at Well # 14. This decline in static level measurements is less than the historic decline of over 3 ft per year. Observations of the groundwater levels during this four-year period show a decrease in the native groundwater level decline. However, full evaluation of groundwater level trends will require long-term monitoring and analysis.

Specific capacity values do not indicate that well clogging is a problem at this time. Water quality sampling for Cycle 5 included monitoring for field parameters and geochemical parameters. Water quality results were consistent with results from Cycles 1, 2, 3, and 4. There is no indication at this time of clogging due to chemical interactions.

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CITY OF PENDLETON

AQUIFER STORAGE AND RECOVERY (ASR) PROJECT

FOURTH ANNUAL REPORT, PILOT TEST, CYCLE 5

INTRODUCTION

The City of Pendleton continues to store high-quality drinking water produced in its membrane filtration water treatment plant in the basalt aquifer system beneath the City. That water is stored during the winter months when there is adequate water in the Umatilla River to provide both for the City's needs and to store excess water in the aquifer. The stored water is recovered during the summer months when demand is high. The process is referred to as Aquifer Storage and Recovery (ASR).

The City began the pilot testing phase of the ASR project in December of 2003. The first phase, Cycle 1, was a brief recharge-storage-recovery cycle to observe hydraulic response in the aquifer. Cycle 1 was completed with assistance from CH2M HILL. The second phase, Cycle 2, began with recharge in January, 2004, continued through storage and recovery, and ended in September, 2004. The third phase, Cycle 3, began with recharge in December, 2004, continued through storage and recovery, and ended in September, 2005. The fourth phase, Cycle 4, began with recharge in December, 2005, continued through storage and recovery, and ended in September, 2006. Pilot tests for Cycle 2, Cycle 3, and Cycle 4 were completed by City staff.

The fifth phase, Cycle 5, of the ASR pilot test began on December 14, 2006 with aquifer recharge at two sites, production well # 1 (Byers Well) and production well # 5 (Stillman Well). Recharge at these wells continued for 136 days until May 14, 2007. Water was stored for a brief, one-day period, and then recovery pumping from Well # 1 began on May 15, 2007. Aquifer recharge was also conducted at a third well, Well # 14, from March 28, 2007 until May 14, 2007. Recovery pumping from Well # 14 began on May 15, 2007 and ended on September 10, 2007. Recovered water is added to the City's distribution system. The recharge rate at Byers Well and Well # 14 is constant; the recharge rate at Stillman Well is variable. The Cycle 5 pilot test was completed by City staff.

The City is conducting the ASR Pilot Testing Program under ASR Limited License # 006 issued by the Oregon Water Resources Department (OWRD) on March 11, 2003 in accordance with OAR 690-350. Procedures and schedules from the Pilot Test Workplan (CH2M HILL, 2000) approved by OWRD are being followed. The limited license requires an annual report, and this report, prepared by City staff, is submitted to fulfill that requirement. This is the fourth annual pilot test report, describing the fourth year of operations, which is ASR Cycle 5. In production of this report, the City has relied on the report by Golder Associates, Inc., entitled *City of Pendleton Aquifer Storage and Recovery (ASR) Project Pilot Test Report (Cycles 1 and 2)*.

ASR OBJECTIVES

The City has met several of its objectives with the ASR project. The project has demonstrated aquifer recharge, storage, and recovery as a viable method for Pendleton to store and recover treated water and assist with reducing native groundwater declines. The ASR project also allows the City to maximize the effectiveness of the membrane filtration water treatment plant (WTP) by operating the plant at full capacity during the winter and spring months when water rights allow and flow is high in the Umatilla River. Since the treated water is of exceptionally high quality, it is ideal for storage in the underground aquifer. Water quality sampling results have further supported this demonstration, providing information that no significant water chemistry reactions are occurring between the treated surface water being stored and the native groundwater.

Prior to the ASR program, the groundwater level was observed to be dropping at a rate of over 3-feet per year, and the City derived about 62% of its supply from native groundwater and about 38% from the City's old "Springs" source (a series of collector galleries located in the alluvium next to the Umatilla River). Since the ASR program began in 2004, the City has been able to reverse this trend of groundwater and surface water usage and now relies primarily on surface water.

During the 2007 water year and ASR Cycle 5, the City recharged and stored 390.333 MG (million gallons). The City recovered 239.633 MG to the distribution system and another 29.4 MG was flushed to waste. Overall 68.9% of the water stored was pumped from the ASR wells. At Byers Well (Well # 1), 216.75 MG was stored and recovered by September 10, 2007. At that point, the City began using its existing water right permits for Byers Well. A total of 258.209 MG was pumped from Byers Well during the 2007 water year. At Stillman Well (Well # 5), 150.70 MG was stored, but none was recovered to the distribution system due to problems with entrained air at the well. Only 29.40 MG was pumped from Stillman Well between January 29, 2007 and June 22, 2007, and it was all pumped to waste. At Well # 14, 22.883 MG was stored and recovered by June 13, 2007. At that point, the City began using its existing water right permits for Well # 14. A total of 34.394 MG was pumped from Well # 14 during the 2007 water year.

For the overall water supply during the 2007 water year and ASR Cycle 5, the City supplied about 1,644.44 MG to the distribution system. Of this total, about 67.9% (1,116.576 MG) was surface water and about 32.1% (527.864 MG) was native groundwater. This compares with 2006 (Cycle 4), which showed 85% surface water and 15% native groundwater; 2005 (Cycle 3), which showed 58% surface water and 42% native groundwater; and 2004 (Cycles 1 and 2) which showed 87% surface water and 13% native groundwater. (See Table 1)

During the ASR project and the four-year period described above, the overall water supplied to the distribution system has been about 6,298 MG. Of this total, 74.4% (4,685 MG) has been surface water and 25.6% (1,613 MG) has been native groundwater. Observations of the groundwater levels during this four-year period show a decrease in

the native groundwater level decline. However, full evaluation of groundwater level trends will require long-term monitoring and analysis.

CYCLE 5

Recharge & Recovery Summary

Cycle 5 pilot testing began at Byers and Stillman wells when the City began recharge on December 14, 2006. Recharge continued for 136 days and concluded on May 14, 2007. Cycle 5 pilot testing began at Well # 14 on March 28, 2007 and continued for 48 days until May 14, 2007. There were several recharge periods because the availability of water for recharge is dependent on both the Umatilla River levels and the City's consumptive demand. Stop and start dates for Cycle 5 recharge are shown in Table 2. The recharge rate at Byers Well was relatively steady at 1240 gpm. The recharge rate at Stillman Well varied from 250 gpm to 2500 gpm. The recharge rate at Well # 14 was relatively steady at 365 gpm. Table 3 shows Cycle 5 recharge and pumping volumes and rates.

Due to municipal demand, the storage period was very brief, lasting only one day. On May 15, 2007, recovery pumping began at both Byers Well and Well # 14. Recovery pumping continued at Byers Well through the end of the water year, September 30, 2007, for a total of 139 days. Pumping at Byers Well actually continued into the next water year through October, 2007. Recovery pumping at Well # 14 continued through June 13, 2007 for a total of 30 days. Well # 14 was operated intermittently after that until September 10, 2007.

The average recovery rate at Byers Well was 1310 gpm. A total of 216.700 MG was stored at Byers Well, which was recovered by September 10, 2007. Total water pumped from Byers Well for the water year was 258.209 MG, which represents 119.13% of the water recharged. The average recovery rate at Well # 14 was 550 gpm. A total of 22.800 MG was stored at Well # 14, which was recovered by June 13, 2007. The well was operated periodically after that time, and total water pumped from Well # 14 for the water year was 34.394 MG, which represents 150.30% of the water recharged.

Recovery pumping at Stillman Well began on January 29, 2007 and continued until June 22, 2007. Only 34.394 MG (19.51% of the total stored) was pumped from Stillman Well; all of it was pumped to waste. Large amounts of entrained air in the water continued to make it difficult to pump the water into the distribution system. Problems associated with the entrained air included cavitation of booster station pumps, pipe scouring, valve leaking, water hammer, and residential complaints. The City has attempted to address the air entrainment issue in various ways. Water was pumped to waste in 2006 and 2007 to flush the well. On October 30, 2006, Stillman Well was pulled, the pump was rebuilt and lowered, and the foot valve bushing sleeve was repaired. Additional chemical monitoring was also done at that time. On January 23, 2007, the bowls in the well were lowered 90 feet to prevent potential problems from cascading water. The well was pumped to waste for 48 hours (approximately 8.064 MG) beginning January 29, 2007. To date, none of

these measures has solved the air entrainment problem; the City continues to explore alternatives to address the issue.

Water Elevation Levels

Average water levels during recharge and recovery for Byers Well, Stillman Well, Well # 14 and production wells # 2 (Round-Up Well) and # 3 (SW 21st St Well) are shown in Table 4. Water levels were not corrected for antecedent trends or barometric pressure effects, in keeping with the conclusions from *City of Pendleton Aquifer Storage and Recovery (ASR) Project Pilot Test Report (Cycles 1 and 2)*, which determined that antecedent trends were inconsistent and the small range of net water level change was not significant.

Static water levels from baseline to pre-Cycle 6 are shown in Table 5. Cycle 1 pre-recharge static levels, recorded in December, 2003 before Cycle 1 recharge began, were 809 feet for Byers and 811 feet for Stillman. Cycle 2 pre-recharge static levels, which were recorded just after Cycle 1 pumping ended and just before Cycle 2 recharge began in late 2003 and early 2004, were approximately 812 feet at both wells. Cycle 3 static levels were 805 and 809 feet for Byers and Stillman, respectively. Cycle 4 pre-recharge static water levels at Byers and Stillman wells were 803.7 and 802.9 feet, respectively. These levels were recorded just before Cycle 4 began in late 2005 and show a decline in water levels of between 1 and 6 feet during 2005. Cycle 5 pre-recharge static levels at Byers and Stillman were 803.1 and 802.2 feet respectively, which indicates a decline of less than a foot at each well. Cycle 6 pre-recharge static levels at Byers and Stillman, which were made in late 2007 just before Cycle 6 recharge began, were 801.0 and 804.2, respectively. This indicates a decline of about 2 feet at Byers and an increase of about 2 feet at Stillman.

Well # 14 had anomalous water level readings throughout the ASR program. In 2006, Well # 14 was sealed off at a depth of about 870 ft, abandoning the bottom +/- 300 feet of the original hole. Therefore, the hydraulic gradeline for the well has changed and the original 2003 baseline reading no longer applies. In 2006, the pre-cycle 5 water level at Well # 14 was 809.8 ft; in 2007, the pre-cycle 6 water level at Well # 14 was 807.7 ft. This indicates a decline of about 2 feet at Well # 14.

Overall, the water elevation static levels at City wells, as shown in Table 5, indicate a decline from December 2003 to December 2007 of from less than 1 ft to eight (8) ft which represents an annual decline of from 0.2 ft to 2 ft. This decline in static level measurements is less than the historic decline of over 3 ft per year and, therefore, substantiates our conclusion that the ASR project is reducing native groundwater declines.

Flow Rates and Specific Capacity

During Cycle 5, Byers Well had a maximum recorded recharge rate of 1264 gpm and a maximum water level buildup of 36.8 ft, as shown in Table 6. Stillman Well had a maximum recorded recharge rate of 1509 gpm and a maximum recorded water level buildup of 124.8 ft. Well # 14 had a maximum recorded recharge rate of 390 gpm and a maximum recorded water level buildup of 38.3 ft.

During recovery, Byers Well had a maximum recorded pumping rate of 1304 gpm and a maximum drawdown of 21.2 ft. Stillman Well had a maximum recorded pumping rate of 3091 gpm and a maximum drawdown of 174.2 ft. Note that Stillman Well was pumped to waste, so there was no pressure head to overcome which would occur if it had pumped into the distribution system. Well # 14 had a maximum recorded pumping rate of 584 gpm and a maximum drawdown of 64.7 ft.

Table 7 summarizes well performance data for Cycle 5 at Byers Well, Stillman Well and Well # 14. Table 8 summarizes well performance data from baseline through Cycle 5 at Byers Well, Stillman Well, and Well # 14. It should be noted that specific capacity measurements may have been made under different flow rates or over different durations in Cycles 1, 2, 3, 4 and 5. Values were not adjusted for well interference or viscosity variations caused by temperature changes. This may account for any differences in specific capacity measurements between cycles.

Specific capacity during Cycle 5 recharge at Byers Well was measured at 33.7 gpm/ft, which compares with 36.5 gpm/ft during Cycle 4, 84.8 gpm/ft during Cycle 3, 47.0 gpm/ft during Cycle 2 and 46.5 gpm/ft during Cycle 1. Although the Cycle 5 recharge specific capacity for Byers Well is significantly lower than the maximum value recorded during Cycle 3, it is comparable to the other specific capacity values recorded during Cycles 1, 2, and 4.

Specific capacity for Cycle 5 recharge at Stillman Well was measured at 23.5 gpm/ft. This is significantly higher than the Cycle 4 recharge value of 14.84 gpm/ft but lower than the Cycle 3 recharge value of 41.0 gpm/ft, the Cycle 2 recharge value of 79.4 gpm/ft, and the Cycle 1 recharge value of 33.9 gpm/ft.

Specific capacity for Cycle 5 recharge at Well # 14 was measured at 10.8 gpm/ft. This value is comparable to the Cycle 2 value of 11.2 gpm/ft and the Cycle 1 value of 11.0 gpm/ft. Well # 14 was not in the ASR program during Cycles 3 and 4.

Specific capacity during Cycle 5 pumping at Byers Well was measured at 62.8 gpm/ft which is very comparable with the Cycle 4 value of 61.8 gpm/ft. These compare favorably with the recovery specific capacity measured during Cycle 2 of 51.99 gpm/ft. No specific capacity numbers were available for Byers Well for Cycle 3 or Cycle 1 pumping.

Specific capacity during Cycle 5 pumping at Stillman Well was measured at 15.6 gpm/ft which is significantly lower than the Cycle 4 value of 36.9 gpm/ft, the Cycle 3 value of 37.4 gpm/ft, and the Cycle 2 pumping value of 36.43 gpm/ft. Note that Stillman Well was only operated for sixteen days and pumped to waste and not pumped against system pressure during that time. Therefore, the measured specific capacity may not be comparable with previous measurements.

Specific capacity during Cycle 5 pumping at Well # 14 was measured at 18.4 gpm/ft. No other specific capacity values were measured at Well 14 during Cycles 1, 2, 3, or 4. The baseline specific capacity at Well # 14 was 30.1 gpm/ft.

Water Quality Results

Water quality results are included for Byers Well, Stillman Well, and Well # 14. Field parameters are shown in Tables 9, 10 and 11 for Byers, Stillman and Well # 14, respectively. Geochemical parameters are shown in Tables 12, 13 and 14 for Byers Well, Stillman Well, and Well # 14, respectively

During recharge, geochemicals were sampled on January 3, 2007 and May 17, 2007 at Byers Well and Stillman Well. Geochemicals were sampled at Well # 14 on April 2, 2007 and May 7, 2007. During recovery, geochemicals were sampled on May 16, 2007, July 17, 2007 and September 6, 2007 at Byers Well. No recovery geochemical samples were collected at Stillman Well. Geochemicals were sampled at Well # 14 on May 17, 2007, May 30, 2007 and June 11, 2007. Geochemicals were collected post-Cycle 5 ASR on October 16, 2007 at all three wells.

Field parameters for Cycle 5 at Byers Well and Stillman Well are consistent with results from Cycle 3 and Cycle 4. For Cycle 5, all bacti analyses at all three wells were negative for both total and fecal coliforms.

A summary of major cation (sodium, calcium and magnesium) data is shown in tables 15, 16, and 17 for Byers Well, Stillman Well, and Well # 14, respectively. Calcium and Magnesium results for Post Cycle 5 at Byers Well are consistent with values from Cycles 2, 3 and 4. Sodium values for Byers Well are lower than values from Cycles 2 and 3 but higher than the Cycle 4 value. Sodium, Calcium and Magnesium values for Stillman Well are close to recharge water values, which follows since very little recharge water was recovered from Stillman Well. Sodium, Calcium, and Magnesium values for post Cycle 5 at Well # 14 are consistent with Cycle 2 values and Cycle 5 pre-recharge values. At all three wells, the major cation data indicate the water has characteristics of both recharge water and native groundwater, indicating mixing between recharge water and native groundwater.

Since the source water for recharge at all three wells is surface water treated at the City's Water Treatment Plant, it follows that the Geochemical Parameters for the recharge water are the same at all three wells. However, some geochemical parameters measured during recovery show variations with time. At the beginning of recovery, the geochemical

parameters are similar to the recharge water. At approximately 50% recovery, some of the geochemicals begin to look like native groundwater. At 100% recovery, the geochemicals more closely resemble the native groundwater than the recharge water. The geochemical data also indicate mixing between recharge water and native groundwater.

Overall, water quality results were consistent with results from Cycles 1, 2, 3 and 4. There is no indication at this time of clogging due to chemical interactions.

CONCLUSIONS

Cycle 5 of the City of Pendleton ASR Pilot Testing Program under ASR Limited License # 006 was successful. The project has demonstrated that Byers Well, Stillman Well, and Well # 14 are capable of storing large volumes of high quality drinking water in the aquifer system beneath the City. Recovery from Byers Well for all five cycles has been very successful. However, the City experienced problems with recovery from Stillman Well during Cycle 4 and Cycle 5 due to air entrainment issues and is currently exploring alternatives to address the problem. Recovery from Well # 14 was successful during Cycle 5, so Well # 14 will continue to be utilized as an ASR well in the future.

City has been successful in reducing reliance on groundwater sources and now draws most of its drinking water from its surface water source. Static level measurements indicate a decline of up to 2 feet at two ASR wells and an increase of 2 feet at a third ASR well during 2007, which substantiates our conclusion that the ASR Pilot Testing Program is reducing native groundwater declines. However, full evaluation of groundwater level trends will require long-term monitoring and analysis.

Specific capacity values do not indicate that well clogging is a problem at this time. However, specific capacity measurements have not been adjusted for well interference or viscosity variations caused by temperature changes, and measurements may have been taken under different flow rates or over different durations.

Overall, water quality results were consistent with results from Cycles 1, 2, 3, and 4 and do not indicate clogging due to chemical interactions.

**City of Pendleton
Aquifer Storage and Recovery (ASR) Project
Fourth Annual Report, Pilot Test, Cycle 5**

TABLES

Table 1: Water Usage by Source, Cycle 1 through Cycle 5

Water Year (ASR Cycle)	Volume Surface Water	% Surface Water	Volume Groundwater	% Groundwater
2004 (Cycles 1 & 2)	1350 MG	87%	206 MG	13%
2005 (Cycle 3)	914 MG	58%	649 MG	42%
2006 (Cycle 4)	1,304 MG	85%	231 MG	15%
2007 (Cycle 5)	1,117 MG	67.9%	527 MG	32.1%
Total: Water Years 2004-2007 (Cycles 1-5)	4685 MG	74.4%	1613 MG	25.6%

Table 2: Cycle 5 Starting and Stopping

Well	Recharge Start	Recharge Stop	Elapsed Time (Days)	Storage Start	Storage End	Recovery Start	Recovery End	Elapsed Time (Days)
Byers (Well #1)	12/14/06	01/14/07	136	5/14/07	5/15/07	5/15/07	09/30/07*	139
	01/16/07	01/22/07						
	02/07/07	05/14/07						
Stillman (Well #5)	12/14/06	01/14/07	136	5/14/07	ongoing	01/29/07	01/31/07	16**
	01/16/07	01/22/07				02/08/07	02/11/07	
	02/07/07	05/14/07				05/15/07	05/18/07	
						06/18/07	06/22/07	
Well # 14	03/28/07	05/14/07	48	5/14/07	5/15/07	5/15/07	9/10/07*	119

* There were numerous Start and Stop dates for Recovery Pumping from both Byers Well and Well # 14.

** Pump to waste for verification of continued air entrainment.

Table 3: Cycle 5 Recharge and Recovery Volumes

Well	Average Recharge Rate (gpm)	Elapsed Recharge Time (min)	Estimated Total Recharge Volume (Gal)	Average Recovery Rate (gpm)	Elapsed Pumping Time (min)	Estimated Total Pumped Volume* (Gal)	Estimated Recharged Water Recovered‡ (Percentage)
Byers (Well #1)	1240	174,758	216,750,000	1310	197,099	258,209,000	119.13
Stillman (Well #5)	Variable 250-2500	NR	150,700,000	NR		29,400,000**	19.51
Well # 14	365	62,466	22,883,000	550	62,363	34,394,000	150.30

(Gal) Gallons

(gpm) gallons per minute

(min) minutes

NR = Not Recorded

* Total volume pumped from the wells as of 09/30/06, including both recharged water and native groundwater

** Pump to waste for verification of continued air entrainment.

‡ Water recovered may include both recharged water and native groundwater

Table 4: Cycle 5 Average Water Elevation Levels by Well

	Byers (Well #1)	Stillman (Well #5)	Round-Up (Well #2)	SW 21st St (Well #3)	Well # 14
	(ft)	(ft)	(ft)	(ft)	(ft)
Recharge	834.6	837.0	808.4	809.1	842.8
Recovery	786.3	NA	673.3	847.5	762.2

Water levels are recorded in feet (ft) by dedicated data recorders and presented as elevation, in feet above mean sea level.

Table 5: Well Elevation Static Levels, Baseline through Pre-Cycle 6

Well	Baseline (ft)	Post-Cycle 1/ Pre-Cycle 2 (ft)	Pre-Cycle 3 (ft)	Pre-Cycle 4 (ft)	Pre-Cycle 5 (ft)	Pre-Cycle 6 (ft)
Byers Well	809	811.8	805	803.7	803.1	801.0
Stillman Well	811.4	811.9	809	802.9	802.2	804.2
Round-Up Well	809.1	810.9	807.7	805.1	807.1	802.1
SW 21 st St Well	805.5	811.6	814.3	807.4	804.7	804.9
Hospital Well	803.4	810.4	808.7	805.7	NA	NA
Well # 14	817.5*	810.4	808.7	809.6	809.8	807.7

NOTE: All water levels are presented as elevation, in feet above mean sea level. Water elevations were not corrected for antecedent trends, barometric pressure effects, well interference, or viscosity variations caused by temperature changes.

*Well 14 had anomalous water levels prior to the start of the ASR program. In 2006, Well 14 was sealed off at a depth of about 870-feet, abandoning the bottom +/- 300-feet of the original hole. In completing this work, the hydraulic gradeline may have been affected.

Table 6: Cycle 5 Maximum Flow Rates & Water Elevation Levels

Well	Maximum Recorded Recharge Rate (gpm)	Static Water Elevation Before Recharge (ft)	Maximum Water Elevation During Recharge (ft)	Maximum Water Level Buildup (ft)	Maximum Recorded Pumping Rate (gpm)	Minimum Water Elevation During Pumping* (ft)	Maximum Drawdown During Pumping (ft)
Byers (Well #1)	1264	803.1	839.9	36.8	1304	781.9	21.2
Stillman (Well #5)	1509	802.2	927.0	124.8	3091	658.0	174.2
Well # 14	390	809.8	848.1	38.3	584	745.1	64.7

* Maximum pumping rate (in gpm) represents maximum pump rate to the distribution system for Byers Well and Well # 14. For Stillman Well it represents maximum pump rate to waste and not against any pressure head.

(Gal) Gallons

(gpm) gallons per minute

(ft) feet

Table 7: Cycle 5 Well Performance (Specific Capacity) Summary Data

Well	Cycle 4							
	Recharge				Recovery			
	Event Date	Rate (gpm)	Buildup (ft)	Specific Capacity (gpm/ft)	Event Date	Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)
Byers (Well #1)	05/06/07	1248	37.0	33.7	06/20/07	1250	19.9	62.8
Stillman (Well #5)	05/05/07	1226	52.1	23.5	06/19/07	2843	182.6	15.6
Well # 14	05/06/07	391	36.3	10.8	06/19/07	566	30.8	18.4

Table 8: Well Performance (Specific Capacity) Summary Data from Baseline through Cycle 5

Water Year (ASR Cycle)	Byers Well (Well # 1)		Stillman Well (Well # 5)		Well # 14*	
	Recharge (gpm/ft)	Recovery (gpm/ft)	Recharge (gpm/ft)	Recovery (gpm/ft)	Recharge (gpm/ft)	Recovery (gpm/ft)
Baseline	NA	NA	NA	48.6	12.4	30.1
2004 (Cycles 1)	46.5	NA	33.9	NA	11.0	NA
2004 (Cycle 2)	47.0	52.0	79.4	36.4	11.2	NA
2005 (Cycle 3)	84.8	NA	41.0	37.4	NA	NA
2006 (Cycle 4)	36.5	61.8	14.8	36.9	NA	NA
2007 (Cycle 5)	33.7	62.8	23.5	15.6	10.8	18.4

NA = Not Available

NOTE: Specific Capacity measurements may have been made under different flow rates or over different durations in Cycles 1, 2, 3, 4, and 5. Values were not adjusted for well interference or viscosity variations caused by temperature changes.

*Well 14 had anomalous water levels prior to the start of the ASR program. In 2006, Well 14 was sealed off at a depth of about 870-feet, abandoning the bottom +/- 300-feet of the original hole. In completing this work, the hydraulic gradeline may have been affected.

Table 9

FIELD PARAMETERS

Cycle 5

Byers Well

DATE	Temp (°F)	pH	DO (ppm)	ORP (mV)	Conductivity (µS)	Turbidity (NTU)	Total Chlorine (ppm)	Free Chlorine (ppm)	Bacti								
XXXXXXXXX	R	E	C	H	A	R	G	E	B	E	G	I	N	S	XXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
12/18/2006								0.58	0.50	Absent							
12/19/2006	37.5	7.4	13.35	424	71.6	0.13											
12/27/2006							0.65	0.54	Absent								
1/3/2007	41.5	7.7	12.07	451	75.4	0.18	0.52	0.40	Absent								
1/8/2007	42.0		12.42	476	71.2	0.11	0.52	0.40	Absent								
1/18/2007	34.3		14.22	487	75.5	0.05	0.70	0.62	Absent								
2/8/2007	39.3	7.4	13.02	433	72.0	0.09											
2/13/2007							0.68	0.64	Absent								
2/15/2007	43.3	7.1	12.26	419	67.3	0.13											
2/20/2007							0.66	0.61	Absent								
2/22/2007	40.4	7.7	12.28	374	63.2	0.11											
2/27/2007	39.9	7.4	12.55	426	63.4	0.10	0.74	0.70	Absent								
3/5/2007							0.62	0.56	Absent								
3/6/2007	43.8	7.5	10.26	380	70.8	0.11											
3/13/2007	46.2	7.5	11.74	424	59.5	0.13	0.61	0.54	Absent								
3/20/2007	48.1	7.2	11.22	328	59.7	0.08											
3/22/2007							0.54	0.46	Absent								
3/26/2007							0.61	0.54	Absent								
3/27/2007	44.0	7.4	11.99	412	61.1	0.07											
4/2/2007	45.8	7.5	11.10	421	63.3	0.07											
4/6/2007							0.56	0.48	Absent								
4/9/2007							0.60	0.54	Absent								
4/11/2007	44.7	7.7	11.55	414	62.9	0.12											
4/17/2007	49.6	7.7	11.01	410	61.9	0.12	0.60	0.56	Absent								
5/3/2007							0.63	0.59	Absent								
5/7/2007	55.7	7.8	10.34	388	70.0	0.14											

Table 9

FIELD PARAMETERS

Cycle 5

Byers Well

[illegible]

Table 10

FIELD PARAMETERS

Cycle 5

Stillman Well

[illegible]

Well # 14

[illegible]

Table 12**Geochemical Parameters****Cycle 5****Byers Well**

All values listed in the table are in ppm unless otherwise noted. ND indicates Not Detected at the detection limit.

PARAMETERS	Recharge--First 01/03/07	Recharge--Last 05/07/07	Recovery--First 05/16/07	Recovery--50% 07/17/07	Recovery--Last 09/06/07	Post Recovery 10/16/2007
Alkalinity (as CaCO ₃)	27	2.64	30.7	44.6	68.8	81.8
Aluminum (total)	ND	0.0143	ND	ND	ND	ND
Ammonia/N	ND	ND	ND	ND	ND	ND
Barium	0.009	0.00912	0.00975	0.00756	0.00942	0.0115
Bicarbonate	27	2.64	30.7	44.6	68.8	81.8
Calcium	5	18.8	5.63	4.59	5.59	5.24
Carbonate (as CaCO ₃)	ND	ND	ND	ND	ND	ND
Chloride (total)	5	3.94	5.48	6.61	8.18	8.94
Chromium (total)	ND	ND	ND	ND	0.00179	ND
Fluoride	ND	ND	0.108	0.557	0.496	0.745
Hardness (as CaCO ₃)	21	18.7	22.5	17.3	20.8	18.9
Iron (total)	0.03	0.0435	0.0544	0.0560	0.0481	0.0151
Iron (dissolved)	0.03	0.0425	0.0488	0.0574	0.0456	ND
Lead	ND	ND	ND	ND	ND	ND
Magnesium (total)	2	7.16	2.04	1.42	1.65	1.41
Manganese (total)	ND	ND	ND	ND	0.001	ND
Manganese (dissolved)	ND	ND	ND	ND	0.00185	ND
Nickel	ND	ND	ND	ND	ND	ND
Nitrate - N	ND	ND	ND	ND	ND	0.096
Nitrite - N	ND	ND	ND	ND	ND	ND
Phosphorous (total)	0.01	0.0172	0.0158	0.0341	ND	0.385
Potassium	2	1.35	2.03	3.21	4.79	4.59
Silica	15	12.6	15.6	19.8	23.7	19.8
Sodium	4	3.96	5.22	17.9	31.8	30.7
Sulfate	1	0.973	2.93	4.91	9.60	12.3
Total Dissolved Solids	95	27	132	118	132	172
Total Organic Carbon	0.9	0.754	0.740	1.04	0.635	0.483
Total Suspended Solids	ND	ND	ND	ND	ND	ND

Table 13**Geochemical Parameters****Cycle 5****Stillman Well**

All values listed in the table are in ppm unless otherwise noted. ND indicates Not Detected at the detection limit.

PARAMETERS	Recharge--First 01/03/07	Recharge--Last 05/07/07	Recovery--First	Recovery--50%	Recovery--Last	Post Recovery 10/16/2007
Alkalinity (as CaCO ₃)	27	2.67				35.0
Aluminum (total)	ND	0.0110				0.0343
Ammonia/N	ND	ND				ND
Barium	0.009	0.00911				0.0122
Bicarbonate	27	2.67				35.0
Calcium	5	4.56				7.03
Carbonate (as CaCO ₃)	ND	ND				ND
Chloride (total)	5	3.94				5.73
Chromium (total)	ND	ND				ND
Fluoride	0.1	ND				0.156
Hardness (as CaCO ₃)	21	20.0				27.9
Iron (total)	0.03	0.0432				0.254
Iron (dissolved)	0.03	0.0440				0.0157
Lead	ND	ND				0.00240
Magnesium (total)	2	1.77				2.51
Manganese (total)	ND	ND				0.00392
Manganese (dissolved)	ND	ND				0.00194
Nickel	ND	ND				ND
Nitrate - N	ND	ND				0.272
Nitrite - N	ND	ND				ND
Phosphorous (total)	ND	0.0158				0.0223
Potassium	2	1.44				1.65
Silica	15	13.5				13.4
Sodium	4	3.53				6.03
Sulfate	1	0.962				4.90
Total Dissolved Solids	68	35				79
Total Organic Carbon	0.9	0.717				0.830
Total Suspended Solids	ND	ND				ND

Table 14**Geochemical Parameters****Cycle 5****Well # 14**

All values listed in the table are in ppm unless otherwise noted. ND indicates Not Detected at the detection limit.

PARAMETERS	Recharge--First 04/02/07	Recharge--Last 05/07/07	Recovery--First 05/17/07	Recovery--50% 05/30/07	Recovery--Last 06/11/07	Post Recovery 10/16/2007
Alkalinity (as CaCO ₃)	22.5	2.59	38.2	74.5	90.2	84.8
Aluminum (total)	ND	ND	ND	0.0114	ND	0.0107
Ammonia/N	ND	ND	ND	ND	ND	ND
Barium	0.00699	0.00807	0.00654	0.00905	0.0108	0.00748
Bicarbonate	22.5	2.59	38.2	68.9	90.2	67.4
Calcium	4.25	4.86	5.21	8.98	11.5	5.89
Carbonate (as CaCO ₃)	ND	ND	ND	5.6	ND	17.4
Chloride (total)	4.0	4.00	4.13	6.88	8.86	10.3
Chromium (total)	ND	ND	ND	ND	0.00100	ND
Fluoride	ND	ND	0.428	1.16	1.34	2.38
Hardness (as CaCO ₃)	17.4	19.7	20.4	35.1	45.4	21.7
Iron (total)	0.0212	0.0404	0.0529	0.0809	0.178	0.532
Iron (dissolved)	0.0193	0.0408	0.0448	0.0790	0.0972	ND
Lead	ND	0.00102	ND	ND	ND	ND
Magnesium (total)	1.65	1.84	1.80	3.08	4.04	1.69
Manganese (total)	ND	ND	ND	ND	ND	0.00251
Manganese (dissolved)	ND	ND	ND	ND	ND	0.00185
Nickel	ND	ND	ND	ND	ND	ND
Nitrate - N	ND	ND	ND	0.405	0.707	0.261
Nitrite - N	ND	ND	ND	ND	ND	ND
Phosphorous (total)	0.0136	0.0163	0.0175	0.0342	0.0259	0.0193
Potassium	1.30	1.44	2.13	3.5	3.90	3.83
Silica	13.8	13.6	18.6	24.3	25.4	24.1
Sodium	3.3	3.86	8.51	30.3	25.5	37.8
Sulfate	1.1	0.977	1.44	6.01	9.52	6.82
Total Dissolved Solids	62	32	92	147	163	190
Total Organic Carbon	1.20	0.799	0.677	0.546	0.377	0.508
Total Suspended Solids	ND	ND	ND	ND	ND	5.44

Table 15: Major Cations, Byers Well

Cation	Background (mg/L)	Cycle 2, End of Recovery (mg/L)	Cycle 3, End of Recovery (mg/L)	Cycle 4, End of Recovery (mg/L)	Cycle 5 Recharge Average (mg/L)	Cycle 5, End of Recovery (mg/L)	Post Cycle 5 (mg/L)
Sodium	69	44.5	41.2	22	3.98	31.8	30.7
Calcium	18.8	6.67	6.01	5	11.9	5.59	5.24
Magnesium	6.3	2.23	1.66	2	4.58	1.65	1.41

Table 16: Major Cations, Stillman Well

Cation	Background (mg/L)	Cycle 2, End of Recovery (mg/L)	Cycle 3, End of Recovery (mg/L)	Cycle 4, End of Recovery (mg/L)	Cycle 5 Recharge Average (mg/L)	Cycle 5, End of Recovery (mg/L)	Post Cycle 5 (mg/L)
Sodium	26.5	19.4	21.6	NA	3.77	NA	6.03
Calcium	31.5	23.5	19.5	NA	4.78	NA	7.03
Magnesium	12.6	9.15	7.98	NA	1.89	NA	2.51

Table 17: Major Cations, Well # 14

Cation	Background (mg/L)	Cycle 2, End of Recovery (mg/L)	Cycle 5 Pre-Recharge (mg/L)	Cycle 5 Recharge Average (mg/L)	Cycle 5, End of Recovery (mg/L)	Post Cycle 5 (mg/L)
Sodium	60.8	44.5	37.7	3.58	25.5	37.8
Calcium	6.29	7.95	13.7	4.56	11.5	5.89
Magnesium	14.8	2.93	4.27	1.75	4.04	1.69

NA = Not Available